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Feasibility of using Littoral Combat Ship (LCS) for Humanitarian Assistance / Disaster Relief (HA/DR) operations

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THESIS

FEASIBILITY OF USING LITTORAL COMBAT SHIPS (LCS) FOR HUMANITARIAN ASSISTANCE / DISASTER RELIEF (HA/DR) OPERATIONS

by

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The thesis focuses on two main areas. The first is to study the feasibility of the LCS to conduct HA/DR operations. The second is to study the HA/DR operations functional allocation, and propose possible Concepts of Operations (CONOPs) and mission package for the LCS to effectively carry out the operations.

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FEASIBILITY OF USING LITTORAL COMBAT SHIPS (LCS) FOR HUMANITARIAN ASSISTANCE / DISASTER RELIEF (HA/DR) OPERATIONS

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LIST OF ACRONYMS AND ABBREVIATIONS

AAW	Anti-Aircraft Warfare
ACI	Acoustic Intercept
ALMDS	Airborne Laser Mine Detection System
AMNS	Airborne Mine Neutralization System
ARG	Amphibious Readiness Group
ASW	Antisubmarine Warfare
C2	Command and Control
CLF	Combat Logistics Force
COBRA	Coastal Battlefield Reconnaissance and Analysis
CONOPS	Concept of Operations
CSG	Carrier Strike Group
DoD	Department of Defense
ESG	Expeditionary Strike Group
GD	General Dynamics
HA/DR	Humanitarian Assistance / Disaster Relief
ISO	International Organization for Standardization
ISR	Intelligence, Surveillance and Reconnaissance
IW	Irregular Warfare
JFEO	Joint Forcible Entry Operations
LCAC	Landing Craft, Air Cushion

LCS	Littoral Combat Ship
LCU	Landing Craft Utility
LM	Lockheed Martin
LPD	Landing Platform Dock
LSD	Landing Ship Dock
LWT	Lightweight Tow
MCM	Mine Countermeasures
MFTA	Multifunction Towed Array
MPCE	Mission Package Computing Environment
MSC	Military Sealift Command
MSM	Maritime Security Mission
MVCS	Multiple Vehicle Communications System
NCW	Network Centric Warfare
NECC	Navy Expeditionary Combat Command
NGO	Non-Governmental Organization
OAMCM	Organic Airborne Mine Countermeasures
OASIS	Organic Airborne and Surface Influence Sweep
OR	Operations Research
OTH	Over the Horizon
OTW	Other Than War
O&S	Operations and Support
PSU	Port Security Unit
RFP	Request for Proposal
RMMV	Remote Multi-Mission Vehicles

SC	Support Containers
SLOC	Sea Lines of Communications
SUW	Surface Warfare
TSCE	Total Ship Computing Environment
UN	United Nations
UNJLC	United Nations Joint Logistics Center
U.S.	United States
US3	Unmanned Surface Sweep System
U.S.A.F	United States Air Force
USV	Unmanned Surface Vehicle
VBSS	Visit, Board, Search, and Seizure
VDS	Variable Depth Sonar
VLS	Vertical Launch System
VTUAV	Vertical Takeoff Unmanned Air Vehicle

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EXECUTIVE SUMMARY

The Navy's primary concern from 1889 to 1989 was "sea control," where naval planners prepared to fight the world's great naval forces in blue water. However, after the Cold War, the United States (U.S.) Navy found itself in a debate on the need for naval transformation. It was realized that the era of sea control was over, and the new challenge was fighting in the littorals. The new threat environment consists less of large blue-water navies and more of smaller, more agile, and possibly high-tech threats, fighting in littoral regions. The Navy soon realized the need for a ship capable of operating in littoral areas, successfully engaging fast and agile vessels and able to incorporate unmanned technologies defensively and offensively. Despite congressional doubts, design and development of the modular, mission-focused Littoral Combat Ship (LCS) continued. In 2003, the Navy launched Sea Power 21 transformation plan. Sea Power 21 (Clark, 2002) emphasizes the building of decisive war-fighting capabilities around three concepts: Sea Strike, Sea Shield, and Sea Basing. The newly developed LCS will play an integral role in Sea Power 21, especially in Sea Shield, contributing its ability to respond quickly, operate in littoral areas, and conduct focused missions with its suite of mission packages.

Over the years, the number of disasters reported each year was increasing. Recent examples include the Indian Ocean tsunami (2004), Hurricane Katrina (2005), the Haitian earthquake (2010) and the most recent Japanese earthquake (2011). The Department of Defense (DoD) has always been at the forefront of Humanitarian Assistance / Disaster Relief (HA/DR) operations throughout the globe and is increasingly taking the lead in initial-response efforts. The Navy plays a large part in such operations with its global naval force. The use of surface ships, generally in the form of an Expeditionary Strike Group (ESG) or Carrier Strike Group (CSG), has greatly enabled the Navy in undertaking this responsibility effectively.

A Systems Engineering study is conducted to examine the feasibility of using the LCS in HA/DR operations. Through the problem formulation, it was observed that big decks, e.g., Aircraft Carriers and Amphibious ships have the capability to travel long distances, and the capacity to carry large amount of cargo. However, they may be slow

and are unable to dock at ports due to their large draft. Smaller ships, e.g., Destroyers, and Cruisers have high speed, and low draft, but do not have the capacity to carry cargo. The Navy thus needs to look into other available means, concepts of operations, and platforms for a more efficient and effective manner of conducting HA/DR operations.

Major stakeholders and their primary needs are then identified and examined. These stakeholders include the disaster victims, the host nation government, Non-Governmental Organizations (NGO) and the military. The primary need is to assist the disaster victims to stay alive, look for the missing, and also to rebuild the nation.

A functional decomposition and mission requirements based on the capability need and stakeholder views are developed. The functional decomposition outlines the set of functions to be accomplished for any HA/DR operations. These functions are then mapped to mission requirements for the Navy. Generally, the Navy will only provide HA/DR operations in the form of immediate relief aid, particularly to supply relief aid, co-ordinate relief aid efforts and also to provide security for HA/DR operations for the humanitarian actors. From the mission requirements, a set of classification metrics is developed to help assess the feasibility of the LCS in HA/DR operations. The assessment of the ship was conducted by understanding the ships' capability and rating the capability with accordance to the classification.

The assessment was done on the LCS, Aircraft Carriers and Amphibious ships. In comparison with the Aircraft Carrier and Amphibious ships, the LCS with its current set of mission packages seems to be slightly lacking in the ability to conduct HA/DR operations. While the LCS excels in speed, shallow draft and it having a full suite of sensors, there are some shortcomings including, limited capacity to carry cargo and personnel, limited medical support facilities onboard, and also limited endurance when travelling at sprint speed.

To help overcome the shortcomings of the LCS in conducting HA/DR operations, the Irregular Warfare (IW) mission package is studied. The mission package is designed with the following considerations: Modularization, Standardization and Training and consists of the following mission modules: Personnel Berthing and Support, Cargo

Capacity, Medical Support, Material Handling, Search and Rescue and Self Defense. The IW mission package is meant for the LCS to be more effective and efficient at conducting HA/DR operations.

Despite the limitations in cargo and personnel capacity and lack of medical support, the LCS is still deemed as a feasible solution to conducting HA/DR operations, due to its high sprint speed, which allows the LCS to reach the disaster region faster than any other ships, especially if the IW mission package is adopted. The mission requirements assessment shows that the LCS with IW mission package shows improvements in capacity to carry cargo and personnel and medical support and thus is better suited to carry out HA/DR operations. The HA/DR Concept of Operations (CONOPS) is developed for the LCS so that they can be better prepared to conduct HA/DR operations. The LCS HA/DR CONOPs does not differ much from the combat CONOPS in terms of employment. There are two main types of deployment, mainly: Integrated with Carrier Strike Group (CSG) / Expeditionary Strike Group (ESG) and Independent Operations. The CONOPs for both types of employment are discussed.

This thesis adopted the Systems Engineering approach, in which the problem is first formulated and analyzed. The development of the functional decomposition and mission requirements is vital to the study of the feasibility of using the LCS in HA/DR operations. Beyond the study of the feasibility, the thesis also discusses the physical allocation, in which a fourth mission package is designed to enable the LCS to conduct HA/DR operations more efficiently and effectively. Specific CONOPs are also developed to better prepare the LCS in conducting the HA/DR operations.

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I. INTRODUCTION

A. BACKGROUND

The United States (U.S.) Navy is "organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea" (Work, 2004). The Navy inventory consists of ships, submarines, aircraft, unmanned systems, and the men and women who operate the equipment. Ships are the Navy's strongest assets, comprising aircraft carriers, surface combatants such as cruisers, destroyers, frigates, amphibious ships, mine-warfare vessels, combat-logistics-force ships and other auxiliary and support craft such as command ships and ocean-surveillance vessels.

The fall of the Soviet Union resulted in a long-running debate on the need for naval transformation. Beginning with the end of the Cold War in the early 1990s, the Navy has experienced a changing threat environment. The new threat environment consists less of large blue-water navies and more of smaller, more agile, and possibly high-tech threats. Potential adversaries are likely to fight in littoral regions, employing the use of small, littoral surface crafts, diesel submarines, shore-based missiles, and asymmetrical mines. Additionally, the Navy must contend with the rapid development of high-tech, unmanned vehicles, whether aerial, surface, or underwater. The Navy realized the need for a ship capable of operating in littoral areas, successfully engaging fast and agile vessels and able to incorporate unmanned technologies defensively and offensively. This led to the design and development of the modular, mission-focused Littoral Combat Ship (LCS).

In 2004, the Navy awarded LCS building contracts to two teams, Lockheed Martin (LM) and General Dynamics (GM). The teams had different hull-type designs, with the LM version a steel, semi-planning, advanced steel monohull (See Figure 1), and the GM version a less-traditional aluminum trimaran hull (O'Rourke, 2012), shown in Figure 2.

Figure 1. Lockheed Martin LCS design (From HIS Jane's, 2012a)

Figure 2. General Dynamics LCS design (From HIS Jane's, 2012b)

Both LCS designs adopt a unique, newly developed mission-modular technology. The LCS seaframe forms the core of the LCS and possesses inherent self-defense capabilities only. The LCS seaframe can be augmented with different warfare-mission packages to adapt to missions in three domains: Mine Countermeasures (MCM), Antisubmarine Warfare (ASW), and Surface Warfare (SUW). The interchangeable

mission packages are used to configure the LCS for different missions, installing quickly to fulfill a mission and uninstalling for storage when not required (NAVSEA Warfare Center). As seen in Figure 3, the mission package essentially consists of mission systems (MS), support equipment, and crew and support aircraft.

Figure 3. LCS Mission Package (From NAVSEA Warfare Center)

In recent years, there has been an increase in the number of Humanitarian Assistance / Disaster Relief (HA/DR) operations, such as those deployed after the Indian Ocean tsunami (2004), Hurricane Katrina (2005), the Haitian earthquake (2010) and the most recent Japanese earthquake (2011). For all these disaster occurrences, large, coordinated, and fast response is required. The Department of Defense (DoD) has always been at the forefront of disaster response throughout the globe and is increasingly taking the lead in initial-response efforts. The Navy, as part of a global naval force, assumes a large part of the responsibility in ensuring the leadership of the DoD in HA/DR efforts. The use of surface ships, generally in the form of an Expeditionary Strike Group (ESG)

or Carrier Strike Group (CSG), has greatly enabled the Navy in undertaking this responsibility effectively.

Speed is a significant priority in delivering relief aid to disaster areas. The LCS, designed to be fast and agile, addresses this priority. The LCS is expected to add to current capabilities because it can speed to a disaster area faster than an ESG or CSG and get closer to shore because of its shallow draft.

B. RESEARCH QUESTIONS

This thesis examines the LCS and studies its feasibility in HA/DR operations. The following questions help guide this study:

- What are the functions and requirements for ships deployed for HA/DR operations?
- What is the feasibility, and possible advantages or shortcomings of using LCSs for HA/DR operations?
- What are the possible concepts of operations involving the use of the LCS?
- What is a possible logistical mission package required for an LCS for HA/DR operations?

C. BENEFITS OF THE STUDY

This study provides insight on the functional decomposition and mission requirements for a HA/DR operation through a Systems Engineering study. The mission requirements are then applied to the LCS to determine its feasibility in HA/DR operations and the logistical mission package required. Additionally, the study provides insight on the comparative capabilities between the LCS, Aircraft Carriers and Amphibious ships for HA/DR operations.

D. ORGANIZATION OF THE DOCUMENT

Chapter II consists of a literature review of the LCS and recent HA/DR operations, exploring their background and requirements. Chapter III defines the problem and describes a Systems Engineering approach. Chapter IV provides a study on the feasibility of the LCS in HA/DR operations, suggested Concept of Operations, and an insight in the possible logistical-mission package for the LCS. Chapter V provides a conclusion and recommendations for future studies and work.

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II. LITERATURE REVIEW

A. LCS PROGRAM

1. History

The U.S. Navy originally performed three broad missions: protecting U.S. overseas trade and interests; defending the American coast from attack; and conducting commerce raiding. This led to the Navy developing relatively short-range coastal defense ships operating in home waters and long-range combatants located overseas. In 1883, with the development of the steel steam-powered cruiser, Congress approved a naval-transformation program that was to eventually result in the "new Navy." The new-Navy strategy required the fleet to be organized, trained, and equipped to destroy any opposing enemy fleet and to establish "control of the seas" (Work, 2004). This resulted in a fleet structure consisting of large battleships and armored cruisers; an intermediate class of cruisers and gunboats; and a new class of small "torpedo-boat destroyers." It was here, during the battleship era, that the U.S. Navy moved up to second place among world navies and by World War II surpassed the British Royal Navy as the premier naval power.

The shift from the battleship era to the carrier era occurred during World War II, when the aircraft carrier became the preeminent ship in the Navy's total-ship battle force. The main difference between the two eras was the deployment of the fleet in battle. During the battleship era, the Navy trained to fight as a single war-fighting entity. By contrast, during the carrier era, the battle fleet operated in wide-ranging, dispersed, carrier task groups, made possible by the growing numbers of aircraft carriers in the Navy and the improved range and fighting power of the aircraft. The fleet's operational architecture also evolved during the shift to the carrier era. Instead of viewing the fleet as a single, concentrated battle line, the fleet was viewed as independent strike groups, capable of accomplishing missions themselves or combining in different ways to complete missions. Such operational architecture made the battle fleet more flexible and improved its ability to exert influence over a wider geographic area than during the battleship era. Said

another way, the battle fleet had transformed itself from a *concentrated striking force to a dispersed striking force capable of concentration* (Work, 2004).

Various technological advances achieved during the carrier era now suggest an impending shift to a new battle-fleet model. First, the introduction of a new missile-launching system—the Vertical Launch System (VLS)—resulted in the dramatic reduction of special purpose, above-deck launchers on fleet surface combatants. The compact nature of the VLS allows smaller-hulled ships to be equipped with antiaircraft warfare (AAW) combat systems. As a result, the offensive striking power of the carrier-era fleet will no longer be concentrated on the carrier decks. Instead, other surface combatants and submarines will augment the carriers, increasing their striking power. Second, the focus is on Network-Centric Warfare (NCW), which hinges on the idea of linking widely distributed fleet sensors and defensive and offensive firepower to form coherent joint and fleet "battle networks." It is thought that the sensory and defensive and offensive capabilities of the battle fleet will be improved by having a large number of manned and unmanned systems, instead of relying on small numbers of heavily armed ships. Finally, the development of unmanned systems has sparked interest in the incorporation of unmanned technology into NCW. The increasing cost of manpower is also an impetus towards unmanned systems. In unmanned systems, the sensor capability of the battle network is greatly enhanced, enabling the battle fleet to see farther and more, without the danger of losing men in the process. These factors prompt naval planners to envision a model where the battle fleet's sensory and defensive and offensive striking power is distributed across large numbers of highly networked manned and unmanned systems, enabling the battle fleet to strike precisely and lethally (Work, 2004).

After the Cold War, the Navy found itself disoriented by the lack of a first-class naval opponent. The Navy's primary concern in the hundred years from 1889 to 1989 was "sea control," where naval planners prepared to fight the world's great naval forces in blue water. These forces included the British Royal Navy and, during the Cold War, the Soviet fleet. It was soon realized that the era of sea control was over and that the new challenge was fighting in littoral areas. As Admiral Jay Johnson, then Chief of Naval Operations, stated in the *Naval Operational Concept* in 1997:

> Our attention and efforts will continue to be focused on operating in and from the littorals. The landward side of the littoral can be supported and defended directly from the sea. It encompasses areas of strategic importance to the United States. Seventy-five percent of the Earth's population and a similar proportion of national capitals and major commercial centers lie in the littorals. These are the places where American influence and power have the greatest impact and are needed most often. For forward-deployed naval forces, the littorals are a starting point as well as a destination. Tactically, the distance we reach inland from the sea depends on terrain and weather, the contributions of joint and coalition forces, the potential adversary's capabilities, and the nature of our mission. The mission may require us to exercise our considerable reach and operate far inland. (Johnson, 1997)

In 1998, Vice Admiral Arthur Cebrowski, then the head of the Naval War College and Navy Warfare Development Command, emphasized that the new fleet should become the nation's "assured access" force. Assured access refers to the ability of the fleet to overcome coastal defenses to enable air (and in some circumstances, ground) forces to conduct operations on or over enemy territories (Martin , 2010). The underlying purpose is the destruction of the enemy in its own littoral regions, for the Navy to gain access into the littorals and the enemy territories. This would be accomplished by the Navy's main battle force, with small networked combatants, which he termed "streetfighters," conducting the engagement seaward of the littorals, protecting the main battle force and destroying enemy coastal assets. The concept of small combatants in the Navy fleet aroused much debate. Despite congressional doubts, development of the LCS proceeded. On November 1, 2001, the Navy announced that it would issue a revised request for proposal (RFP) for its future surface-combatant program, known as "DD(X)" and comprising three new ships: a large multi-missile destroyer; a large multi-mission, guided-missile cruiser; and a small "focused mission" Littoral Combat Ship. The. Navy plans to field fifty-five LCS sea frames and sixty-four mission packages, consisting of sixteen ASWs, twenty-four MCMs, and twenty-four SUW packages (O'Rourke, 2012).

2. Design Requirements

The LCS is a highly capable, multi-role, but mission focused, small combatant that enables the Navy to project into littoral regions and leverage the technology of

unmanned vehicles and weaponry to defeat the enemy in its own territory. The LCS is to perform surface warfare, mine countermeasure, or antisubmarine warfare in the littoral regions, independently or as part of a distributed naval battle network. The contract to build the LCS was awarded to both Lockheed Martin and General Dynamics, with the following main design requirements (Martin, 2010).

a. Independent Operations

While the LCS can operate as part of a CSG/ESG, it must be capable of carrying out independent operations over distances between 3,500 and 4,300 miles, travelling at economical speed while carrying between fourteen and twenty-one days of provisions. This mandate drives the requirements for seaworthiness, bunker capacity, and habitability.

b. Modularity

Modularity is the heart of LCS design. The LCS is intended to carry out "plug and play" modules, known as mission packages, which can be changed out within forty-eight hours, according to the mission assigned to the ship. This modularity enables the commander to adjust ship configuration to assigned mission requirements with ease. The mission packages emphasize manned and unmanned off-board systems, sensors, and weapons systems.

c. Speed

The LCS is designed to have a high sprint speed in excess of 40 knots and a high sustained speed to enable it to run along a 30+ knots CSG or 20+ knots ESG. The high sprint speed enables the LCS to reach its mission destination much faster and is also integral to avoiding hits by complicating enemy targeting, allowing quick repositioning against threats, and evading torpedoes (O'Rourke, 2012)—thereby improving its susceptibility and survivability.

d. Battle Network Capability

The LCS's ability to network with other naval and air assets enables it to exchange tactical and operational data and information with other platforms. The LCS is

also able to act as a forward command-and-control (C2) hub, controlling not only its own off-board assets, but also similar assets deployed by other platforms located over the horizon (OTH). This ability enables the LCS to perform scouting missions effectively, especially those involving antisubmarine and mine countermeasures. The figure below provides an overview of this battle network capability.

Figure 4. LCS Battle Network Capability (From Navy Warfare Development Command, 2003)

3. LCS mission packages

The LCS is a fast, agile, mission-focused, networked, small surface combatant, optimized for operating in littoral regions. An important capability of the LCS is its ability to rapidly install interchangeable mission packages onto the seaframe to suit different missions. Each mission package can be quickly installed onto the seaframe for a

specific mission and then uninstalled, maintained, and stored for future use aboard any other LCS seaframe (Office of Corporate Communication (SEA 00D), Naval Sea Systems Command, 2011).

A mission package essentially consists of mission modules, mission-crew detachments, and support aircraft. A mission module comprises all the equipment, hardware, and software required for a particular mission type and is integrated with the LCS seaframe. Some examples of mission modules include mission systems (vehicles, sensors, communications, and weapon systems), support equipment, mission-package computing environment (MPCE) hardware and software, and multiple-vehicle communications system (MVCS) hardware and software. The MPCE provides the information-technology infrastructure for mission packages operations and the required network interfaces to the total-ship computing environment (TSCE). Mission packages can be swapped easily to reconfigure an LCS for different missions in a short time. Mission equipment fits inside standard ten- or twenty-foot International Organization for Standardization (ISO) support containers (SCs), or on ISO-compliant flat racks and vehicle cradles. The use of standardized ISO SCs facilitates logistics in shipping, storage, equipment handling, and container movement. Mission package reconfiguration can be done in homeport or overseas, using prepositioned mission packages or mission packages transported into theaters and staged near LCS operating areas (Office of Corporate Communication (SEA 00D), Naval Sea Systems Command, 2011). There are currently three different mission packages for the three focused mission areas of mine-countermeasure, antisubmarine, and surface warfare.

a. Mine-Countermeasure Warfare (MCM) mission package

The MCM mission package allows the LCS to transport and deploy manned and unmanned off-board surface and semisubmersible vehicles with MCM sensors and systems to the vicinity of the minefield, while remaining outside the mine threat itself. This way, sailors are kept out of danger while mine threats are neutralized. The suite of off-board sensors and systems will be used to detect, localize, neutralize, and sweep mines, if necessary. MCM-configured LCSs will thus be able to clear transit lanes

for CSG/ESG, or clear larger operating areas to facilitate joint forcible-entry operations (JFEO) (Program Executive Office, Littoral Combat Ship [PEO LCS]). The baseline MCM mission package includes:

Mission Module	Features
Organic Airborne Mine Countermeasure (OAMCM) Module	- MH-60S helicopter - Airborne Laser Mine Detection System (ALMDS) - Airborne Mine Neutralization System (AMNS) - Organic Airborne and Surface Influence Sweep (OASIS) - AN/AQS-20A Mine hunting sonar - MH-60S support container - OASIS support container - OAMCM Mission Kit support container - ALMDS/AMNS support container - AN/AQS-20A support container - Organic Cable Reeling Assembly - Organic Post Mission Analysis (OPMA) workstation
Influence Mine Sweep Module	- MCM Unmanned Surface Vehicle (USV) - Unmanned Surface Sweep System (US3) - USV support container - USV cradle
Coastal Mine Reconnaissance Module	- Vertical Takeoff Unmanned Air Vehicle (VTUAV) - Coastal Battlefield Reconnaissance and Analysis (COBRA) - VTUAV support container - COBRA-PMA workstation
Remote Mine Hunting Module	- Remote Multi-Mission Vehicles (RMMVs) (2) - AN/AQS-20A Mine hunting sonars (2) - RMMV cradles (2) - RMMV capture spindles (2) - RMMV container - AN/AQS-20A support container
MP Application Software	- Mission specific application software that supports the MP in planning and executing the MCM Missions.

Table 1. MCM Mission Package (From Program Executive Office, Littoral Combat Ship [PEO LCS])

b. Antisubmarine Warfare (ASW) mission package

The ASW mission package enables the LCS to provide joint-force commanders with the capability of conducting detect-to-engage operations against modern diesel-electric and nuclear submarines in littoral areas, defeating those that pose

an immediate threat. Specific ASW capabilities include protecting forces in transit, protecting joint operating areas, and establishing an ASW barrier in shallow littorals and deep-water approaches to littorals. The ASW-configured LCS can conduct ASW missions in support of a CSG/ESG, or while operating as part of an LCS surface action group, or independently (Program Executive Office, Littoral Combat Ship (PEO LCS)). The baseline ASW mission package includes:

Mission Module	Features
ASW Escort Module	- Variable-depth sonar (VDS) - Multifunction towed array (MFTA) acoustic receiver - Launch, handling, and recovery equipment - Signal processing and systems control - Support containers
Torpedo Defense Module	- Alertment: MFTA with Acoustic Intercept (ACI) - Countermeasures: Lightweight Tow (LWT)
Aviation Module	- MH-60R Helicopter w/ALFS - Vertical-Takeoff Unmanned, Aerial Vehicle (VTUAV) (2) - Support containers
ASW Mission Management / C2 Center	- Mission-package application software - Networks that interface with the total-ship computing environment

Table 2. ASW Mission Package (From Program Executive Office, Littoral Combat Ship [PEO LCS])

c. *Surface Warfare (SUW) mission package*

The SUW mission package is designed to provide fleet protection from small boats and other asymmetrical threats. Other than field protection, the SUW mission package allows the ship to provide operational security in interdiction missions against terrorist suspects and high-seas pirates, and also provide defense against shore attacks while operating in the littorals. The SUW mission package augments the core LCS sensors and weapons capabilities with guns, missiles, and aviation systems, enhancing the safety of sailors operating the LCS (Office of Corporate Communication [SEA 00D], Naval Sea Systems Command, 2011). The baseline SUW mission package includes:

Mission Module	Features
Gun	- MK 46 MOD (X) Gun Weapon System with MK 44 MOD 2 30mm Automatic Cannon - Uses all Navy qualified 30mm and 173mm ammunition - 400 rounds in turret - Two ready service magazines with 240 rounds each - Three shipping containers
Surface-to-Surface Missile	- Surface-to-surface missiles capable of engaging fast-moving small-boat threats - Launcher systems with self-contained technical fire control - Hatch system / support structure / module service panels - Gas management system - Module control computer
Aviation Module MH-60R Helicopter	- MK 299 MOD 2 launchers with 8 HellFire missiles - GAU21 .50 caliber machine gun - M240 7.62mm machine gun - Two support containers - Vertical-takeoff, unmanned, aerial vehicle (2) - One support container
Maritime Security	- Two 11m rigid-hull inflatable boats (RHIBs) with cradles and parts - Two berthing modules with gear storage - One head and shower module - Visit, board, search, and seizure (VBSS) gear - Boarding teams
MP Application Software	- Mission-specific application software that supports the MP in planning and executing SUW missions.

Table 3. SUW Mission Package (From Office of Corporate Communication [SEA 00D], Naval Sea Systems Command, 2011)

4. Concept of operations

Sea Power 21 (Clark, 2002) emphasizes the building of decisive warfighting capabilities around three concepts: Sea Strike, Sea Shield, and Sea Basing. LCS will play an integral role in Sea Power 21, especially in Sea Shield, contributing its ability to respond quickly, operate in littoral areas, and conduct focused missions with its suite of mission packages. The Sea Power concepts are summarized as follows:

Sea Strike – offers expanded power projection that employs networked sensors, combat systems, and warriors to amplify the offensive impact of sea-based forces;

Sea Shield – global defensive assurance produced by extended homeland defense, sustained access to littorals, and the projection of defensive power deep overland;

Sea Basing – enhanced operational independence and support for joint forces provided by networked, mobile, and secured sovereign platforms operating in the maritime domain.

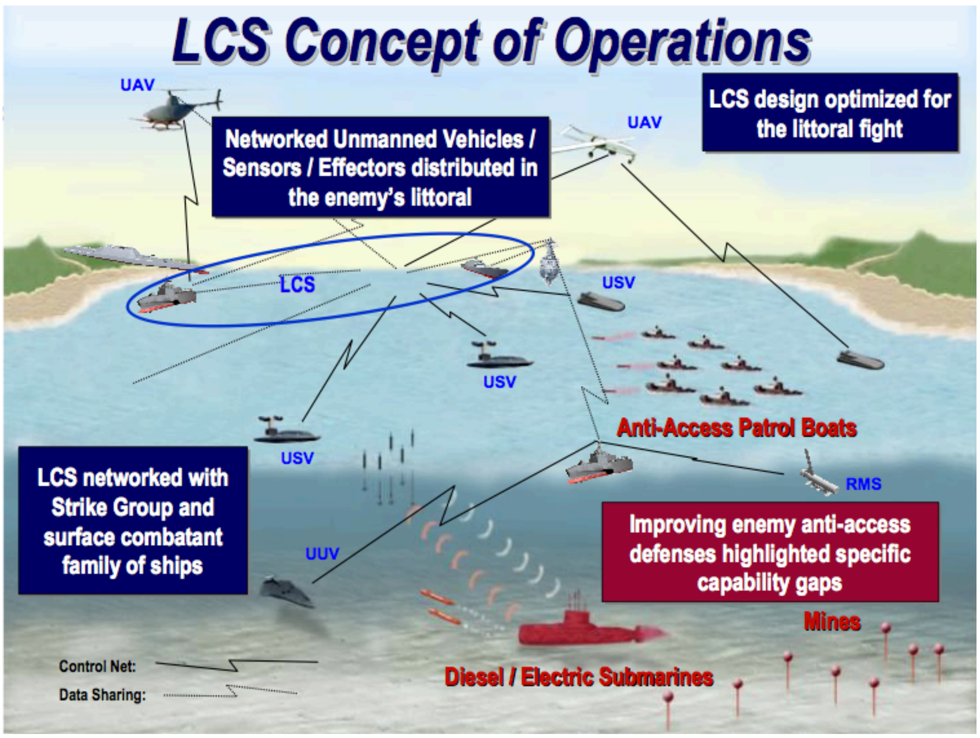

Figure 5. LCS Concept of Operations (From Good, 2007)

As seen in Figure 5, the LCS will constantly be deployed throughout a continuum of operations as part of a distributed force, networked to off-board sensors and power-projection elements, e.g., CSG/ESG. There are two major categories of missions: Focused and Continuing Missions. For Focused Missions, the LCS employs mission packages tailored to perform specific missions, e.g., SUW, MCM and ASW. The LCS deploys as part of a distributed force, where groups of ships may be discretely configured, so that more than one type of mission can by conducted by the force. In Continuing Missions, the LCS will always self-defend, conduct intelligence, surveillance,

and reconnaissance (ISR), deliver personnel and material, perform maritime-interception operations, Sea Line of Communications (SLOC) patrols, conduct information warfare, and participate heavily in force protection (Navy Warfare Development Command, 2003). These missions are made possible by the LCS's wide suite of sensory, command and control, and weapons capabilities.

The employment of the LCS depends largely on the number of available units, the specific scenarios of different theaters, the requirements of the global naval concept of operations (Mullen, 2003), and other issues. There are three basic employment methods for the LCS:

a. Integrated with CSG/ESG

The LCS, with tailored mission configurations, would be deployed together with a CSG/ESG, providing vanguard scouting, pouncing support, and other tasking, especially in littoral areas.

b. Divisions Operations

An LCS force would be deployed forward to maintain a continuous presence in theaters of operations. This force will use its speed to be the first to reach the theaters and build situational awareness in the littoral in anticipation of other operations. The force will then integrate with joint task-force assets and continue operations.

c. Limited Independent Operations

A single forward-deployed LCS would response quickly and conduct a wide range of missions in a low-threat environment, e.g., SOF support, logistics, medical, HA/DR operations.

The LCS should not be sought for multi-mission capabilities, but should be used more as a focused-mission platform, less capable of handling simultaneous missions. However, when deploying an LCS as part of a squadron, the combatant commander can choose to equip multiple LCS platforms with a mix of mission packages for operational success across a broad range of challenges associated with littoral warfare.

B. U.S. NAVY HA/DR OPERATIONS

On January 12, 2010, at 4:53 p.m Eastern Standard Time, a 7.0 magnitude earthquake struck Haiti (see Figure 6). The devastating earthquake killed approximately 220,000 people, injured 300,000, damaged 188,383 houses, destroyed 105,000 houses and left behind 19 million cubic meters of rubble and debris in Port au Prince (Disasters Emergency Committee). A majority of air- and sea-transport facilities were damaged and declared inoperable. After the earthquake, at least fifty-two aftershocks measuring 4.5 or greater were recorded. The President of Haiti declared a national emergency and requested immediate assistance from the United States and international community (DiOrio, 2010).

Figure 6. Earthquake Epicenter (From DiOrio, 2010)

The U.S. military responded quickly to the request. The U.S. Coast Guard had two cutters near Port au Prince at the time of the quake, and these were joined by four more to conduct an initial damage assessment. Two MC-130s began the distribution of food and water on Day 1. The U.S. Air Force (USAF) sent in 6,000 airmen, including a

Kansas Air Guard engineering squadron to break the logjam at the airport. The Navy mustered thirty-three ships, including Coast Guard vessels, the carrier USS *Carl Vinson*, the hospital ship USNS *Comfort*, the cruiser USS *Bunker Hill*, two Amphibious-Readiness Groups (ARGs)—LHD-5 USS *Bataan* and LHA-4 USS *Nassau,* and their support ships—two Marine Expeditionary Units (the 22nd and 24th), Navy Expeditionary Combat Command (NECC) personnel, and a Port-Security Unit (PSU). Three thousand U.S. soldiers of the 82nd Airborne Division (Global Response Force) from Fort Bragg were deployed to establish a base for distribution of food and water. Within the first week after the earthquake, the U.S. had approximately 17,000 military personnel in and around Haiti for HA/DR operations (DiOrio, 2010).

This example shows the many complexities in responding to HA/DR requests, especially due to the unpredictable nature of the frequency, extent of damage, and type of disaster. The difficulties are compounded by the dynamic nature of the deployment of U.S. forces and the increasing number of disasters reported each year (see Figure 7). HA/DR operations are increasingly common and have become one of the leading other-than-war (OTW) missions of the U.S Navy. From 1970 through 2000, U.S forces were involved in 366 humanitarian missions, a number made more significant when compared to the twenty-two combat-related missions during the same period (Cobble, Gaffney, & Gorenburg). The interest in contributing actively in HA/DR operations can best be seen in the Navy's new "Cooperative Strategy for 21st Century Seapower," where the Navy will continue to mitigate human suffering as the vanguard of interagency and multinational efforts, both in a deliberate, proactive fashion and in response to crises (Department of Navy (DoN), 2007). In 2012, the Chief of Naval Operations, Admiral Jonathan Greenert, emphasized the unwavering support of the U.S Navy for HA/DR operations.

> Some of our friends and international partners have expressed concern that budget reductions will affect the fleet's ability to conduct humanitarian assistance missions. We have a new strategy and some budget changes, but we will continue to answer the call when a humanitarian need arises or natural disaster strikes. Our forward presence allowed us to rapidly respond to tsunamis in Indonesia and Japan, earthquakes in Haiti, or

floods in Pakistan. Because they operate forward and are ready, our deployed ships and sailors help save lives in the critical first days after a disaster. (Greenert, 2012)

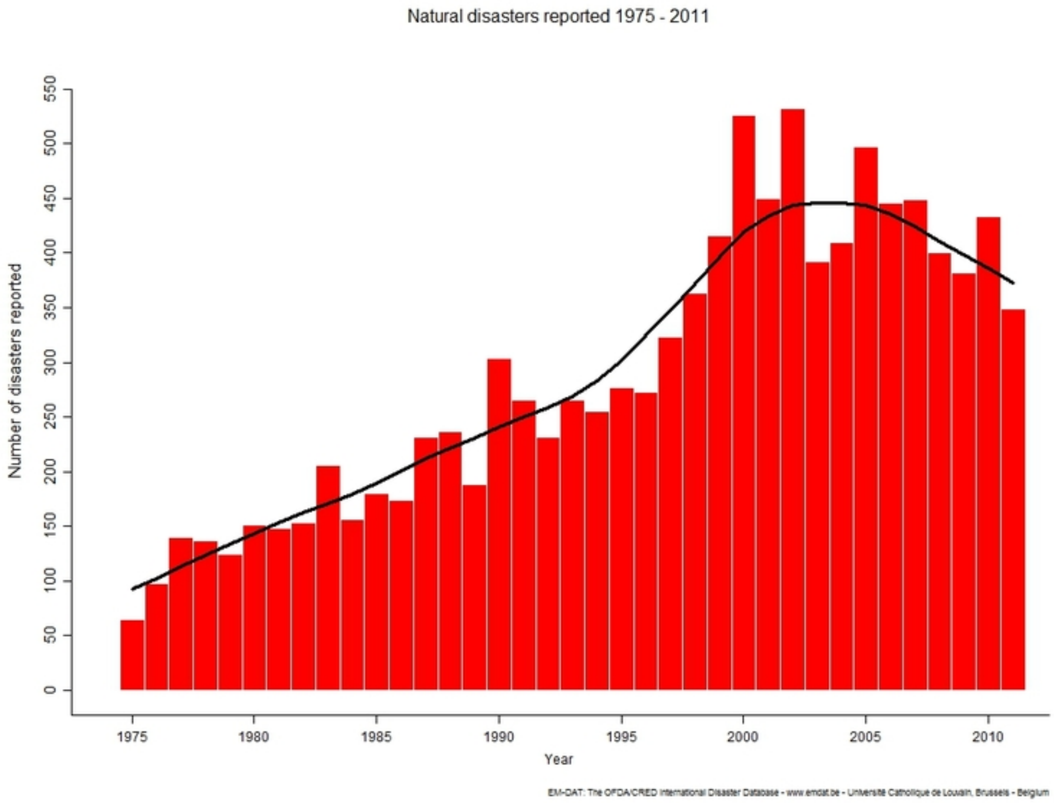

Figure 7. Natural Disasters Trend, 1975 – 2011 (From EM-DAT, 2011)

Regardless of the type of disaster, there are common traits in every major occurrence (EM-DAT, 2011).

Disaster Traits
High number of deaths and injuries
High number of missing persons
Destruction of buildings and homes
Destruction of transportation infrastructure such as airports, seaports, roads, and railways
Increased demand for basic necessities, such as food, water, shelter
Increased demand for medical personnel, medical facilities, and medicine
High amount of debris

Table 4. Disaster Traits

Military support in HA/DR operations is intended to be of short duration i.e., during the crisis stage. Once a situation has stabilized, the United Nations (UN), non-governmental organizations (NGOs) and the host nation should assume the functions conducted by the military (Department Of The Navy, 2005). However, military support is critical in the crisis stage to stabilize the situation, deliver logistics supplies, provide healthcare services, enforce security and peace, and conduct search and rescue. The need for speed in reaching the disaster area is therefore of utmost importance. During Operation Unified, there was a concerted effort by the U.S. Navy to be as forward as possible and reach out to Haiti in the shortest possible time.

> "Since… the first few hours and days are absolutely critical to saving lives and avoiding even greater tragedy, I have directed my teams to be as forward-leaning as possible in getting the help on the ground and coordinating with our international partners as well." President Obama Press conference 13 Jan (Obama, 2010).

The Navy has been the leading force in HA/DR efforts, mainly because it owns multiple assets that have unique capabilities in providing relief efforts. The dispersion of assets across the globe ensures that Navy is always within reach of any area requiring

help. The Navy will, however, need to understand what functions are required and which assets will be most efficient and effective in a specific disaster. To improve its efforts, the Navy will need to incorporate new capabilities, not only in warfighting operations, but also in HA/DR operations.

The Navy has identified HA/DR as a core capability and further divided it into proactive and reactive HA/DR. While both concepts serves the same aim of providing relief, assistance, and support, proactive HA/DR tends towards the humanitarian assistance (HA) part by employing globally distributed, mission-tailored naval forces to address ally and partner needs that may not be directly related to national security, but reflect the values and desires of the American people to render aid and reduce suffering. Reactive HA/DR undertakes similar activities, but the often extreme circumstances and severe risks to the population that characterize such events demand an immediate response that can only be provided by expeditionary naval forces trained and proficient in diverse crisis-response operations (Department of Navy (DoN), 2010).

C. HUMANITARIAN LOGISTICS

Disaster management consists of many processes with several stages. Disaster-relief operations can be divided into three main phases: preparation (activities before the disaster occurs), immediate response (actions taken instantly), and reconstruction (actions in the aftermath) (Kovacs & Spens, 2007). The resources and skills required for each phase differ, and a clear understanding of the different phases enables planners to prepare for HA/DR operations in the event of disaster.

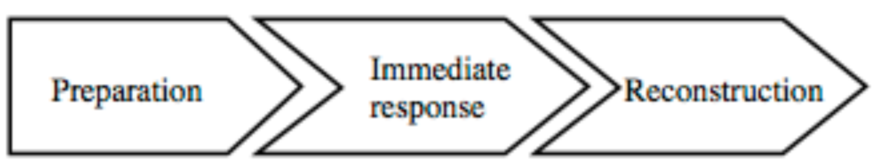

Figure 8. Phases of disaster-relief operations (From Kovacs & Spens, 2007)

1. Preparation phase

The preparation phase describes the activities that can be done prior to a disaster that may alleviate the effects of the disaster on people and infrastructure. These activities can be further segregated into two main areas: the preparedness of people living in disaster-prone regions and the preparedness of aid agencies.

Some regions may be more prone to natural disasters than others, such as those close to an active volcano, hurricane-prone region, or fault line. For such regions, measures can be taken to limit the effects of a disaster. Evacuation plans can be developed and evacuation training can be conducted to familiarize people. Early warning systems can provide notice of impending disaster, e.g., volcanoes' eruptions and incoming hurricanes, so that evacuation-related measures can be taken early to reduce the extent of the damage. Important logistics items such as water, food, medicine, blankets, and tents can be stocked at safe locations to be distributed in time of need.

The preparedness of aid agencies helps them achieve efficiency and effectiveness of operations in the immediate-response and reconstruction phases. Strategic plans can be developed for disasters before they occur to ensure the smooth implementation of relief-aid operations. Stocking up on logistics items and pre-purchasing agreements with suppliers ensures the continuous flow of critical aid. Coordinating many agencies can prove to be challenging, especially when they have their own operating structures. Coordination plans can be prepared during the preparation phase, as aid agencies develop collaborative plans through organizations such as the United Nations Joint Logistics Center (UNJLC) (Kovacs & Spens, 2007).

The challenge to U.S. naval forces is to enhance their ability to conduct HA/DR without degrading their capability and proficiency in conducting more traditional naval missions. Given their forward presence, inherent mobility, and flexible capabilities, U.S. naval forces are frequently the "force of choice" for such missions. However, the demands of emergent, reactive HA/DR can affect readiness, logistical sustainment, and operational dwell, and often require contingency funding to reset the units involved (Department of Navy (DoN), 2010).

2. Immediate Response phase

The emergency plans of aid agencies are put in place once a disaster strikes. However, no matter how detailed or prepared an aid agency may be, the unpredictable nature of disasters and the extent of the damage can create obstacles. The immediate response to any major disaster is always to deliver supplies to the region, and supply chains need to be deployed even with very limited information on the situation. The main problems in the immediate-response phase lie in the coordination of supplies, the unpredictability of demand, and the last-mile problem of transporting necessary items to victims (Kovacs & Spens, 2007). Infrastructure almost always poses the greatest challenge in the provision of relief aid in this phase. The existence of entry points into the country, e.g., ports and airports, and the availability of roads and vehicles are vital to delivering supplies to and within the disaster region.

3. Reconstruction phase

The reconstruction phase helps providing long-term relief aid to victims in a disaster region. Activities include the fixing of damaged homes, supplying survival kits, constructing new homes, and fixing damaged roads. The main aim is to rebuild the region back to what it was before the disaster and help the victims regain their original way of living. Unfortunately, funding is often focused on short-term disaster relief, neglecting the importance of the long-term phase of reconstruction.

III. A SYSTEMS ENGINEERING APPROACH

A. METHODOLOGY

A Systems Engineering approach is adopted to analyze the feasibility of employing LCSs in HA/DR operations. An initial problem definition is formulated, in which the capability need is identified. The capability need in this sense might not refer to a capability gap, but may point to an area of improvement in conducting HA/DR operations and deployment. Major stakeholders and their primary needs are identified. A functional decomposition and mission requirements based on the capability need and stakeholder views are developed. The functional decomposition and mission requirements are used to study the feasibility of the LCS in HA/DR operations, and also shape the Concept of Operations (CONOPS) in the following chapter. The type of logistical mission package required in meeting the requirements for HA/DR operations is also derived in the following chapter.

B. PROBLEM DEFINITION

HA/DR operations have been identified as a core competency in the Navy. The recent increase in disasters occurrence has placed HA/DR at the top of OTW operations. The Navy typically provides relief aid in the preparation and immediate response phase of disaster-relief operations. Relief-aid supplies are stocked up in strategic locations, e.g., selected ships and ports, to facilitate the delivering of supplies to disaster regions. When a disaster strikes, the Navy sizes up nearby ships and sends them to the region as soon as possible to provide an initial provision of supplies and assess the situation, meanwhile preparing other ships to deliver more logistics items and support to the area. Besides delivering supplies, the Navy conducts other relief-aid operations, e.g., port surveys, police and security services, and medical aid, and organizes distribution efforts.

The highlight of HA/DR operations in the immediate response phase is the delivery of items such as food, water, and medical supplies. Big ships like Aircraft Carriers and Amphibious ships have been the top choice in HA/DR operations, due to their large capacity for cargo and personnel. The medical facilities aboard such ships are

also more complete and offer a wider range of medical care. The fuel capacity of these ships is also larger, allowing them to have higher endurance, and travel farther, without refueling. Due to their suitability for HA/DR operations, their crews are trained specifically for such missions.

An example is the Essex Amphibious Readiness Group (ARG), which consists of the forward-deployed, amphibious-assault ship USS *Essex* (LHD 2), and the dock-landing ships USS *Harpers Ferry* (LSD 49), USS *Germantown* (LSD 42) and USS *Tortuga* (LSD 46). The Essex ARG was deployed to provide HA/DR support to Japan after the country was hit by an 8.9 magnitude earthquake and ensuing tsunami in March 2011. The ship crews were trained for HA/DR operations and the ships were equipped with CH-53 Sea Stallion and CH-46E Sea Knight helicopters, which can move more than 260,000 pounds of cargo and 860 passengers per day. The Essex ARG can also make use of amphibious craft, e.g., landing craft, air cushion (LCAC), and landing craft utilities (LCUs), to transport personnel and cargo to shore. Furthermore, the *Essex'* medical department can expand into a 600-bed hospital with a 14-bed intensive care unit and 46-bed inpatient ward. The ship's medical facilities include six operating rooms, three triage stations, X-ray facilities, a blood bank, and a laboratory (Ramsaran, 2011).

Speed is of the essence in any rescue or HA/DR mission. In December 2007, the USS *Ronald Reagan* received a distress call from the *Dawn Princess* cruise ship off the coast of Baja California: a fourteen-year-old girl had a ruptured appendix. The *Ronald Reagan*, which was on maneuvers about 500 miles from the *Dawn Princess*, answered the distress call, sped towards the cruise ship, and got close enough to launch a helicopter. The girl was airlifted back to the ship and medical assistance was rendered, saving her life (Hoffman, 2007). Should the *Ronald Reagan* not have gotten to the cruise ship in time, the girl might not have survived. Similarly, the faster the U.S. Navy can get to a disaster area, the faster it can render relief aid, which may help save many lives. Amphibious ships, such as the Essex ARG, though suitable for HA/DR operations, are relatively slow, with speeds in the 20-knots region. Cruisers and Destroyers are smaller ships with greater speed. However, they lack sufficient cargo capacity and hence have

very limited ability to deliver relief-aid supplies. In terms of size, carrying capacity, and speed, Aircraft Carriers may be the best choice.

The draft of a vessel refers to the distance between the vessel's waterline and the lowest point of the vessel, usually the keel (Bruno). Draft determines the minimum depth of water a ship requires to safely navigate and is a significant factor limiting navigable waterways, shallow coastal waters, and reefs, especially for large ships. The draft of a ship also determines its ability to dock in port, especially ports in shallow waters. Large ships have larger drafts, and hence limitations in maneuvering in shallow waters. The USS *Essex* (LHD 2) has a draft of 26.6 ft. (IHS Jane's, 2011), meaning that it can maneuver only in waters with depths of more than 26.6 ft. The common concept of operations for large ships such as Aircraft Carriers and Amphibious ships is to dock in deeper waters and use secondary mode of transportation, usually helicopters and smaller crafts, e.g., LCACs and LCUs, to transport cargo and personnel to shore. The round trips made under the secondary mode of transportation require many resources, such as the time and personnel used for loading and unloading, as well as the movement to and from the ship and shore. This increases the lead-time needed to deliver supplies and personnel and decreases the efficiency of HA/DR operations.

For a more efficient and effective manner of conducting HA/DR operations, the U.S. Navy needs to look into other available means, concepts of operations, and platforms.

C. STAKEHOLDER ANALYSIS

When a disaster strikes, two groups are most affected: those who require help and those who provide help. The group that requires help is mainly residents of the region, i.e., disaster victims and the host-nation government. The group that provides help is those who stand up in the aftermath to provide relief aid, i.e., humanitarian actors. These may include the military and other non-governmental organizations (NGOs). In this discussion, the military specifically refers to the U.S. Navy. The table below summarizes the primary stakeholders and their primary needs.

Stakeholder	Primary needs
Disaster victims	- To stay alive - To look for the missing
Host-nation government	- To provide for disaster victims - To rebuild infrastructure - To assess extent of damage and request help from international bodies
NGOs	- To provide relief and assistance to disaster victims - To help victims survive the ordeal in the long run
U.S. Military (Navy)	- To provide immediate relief and assistance to disaster victims - To coordinate HA/DR efforts - To conduct security operations

Table 5. Stakeholders' primary needs

Natural and man-made disasters lead to human suffering and create needs that the victims cannot alleviate without assistance. The victims' primary need is to stay alive. In the aftermath of a disaster, victims may find themselves with destroyed homes, broken families, and no access to basic necessities. There is uncertainty as to whether the disaster is over yet (e.g., there may be aftershocks) and if they will be able to receive help from their government. In the period immediately after a disaster, the victims need no more than the necessities to survive, i.e., food, water, medicine, shelter, and nutrition. The other immediate need is to find missing family and friends.

Though faced with the same predicament, the host-nation government must endeavor to help its citizens survive. Beyond simply providing citizens with logistical supplies, the government needs to rebuild basic infrastructure such as medical facilities and roads. Medical facilities should be the main priority. Transportation facilities must be rebuilt to enable delivery from external sources, via seaports and airports, and from internal sources, via roads and railways. More importantly, the government needs to conduct an initial assessment of the damage, size up its deficiencies, and request relief aid from the international community.

When a disaster strikes, a variety of international organizations such as NGOs (several are listed in the table below) play an important role in disaster response. They participate in all three phases of relief operations (Kovacs & Spens, 2007), especially the first and third. The NGOs' aim is typically to provide relief and assistance to victims and help them survive in the long run. Because they are usually structured and organized to provide long-term assistance, they typically carry with them more than first-aid response kits.

S/N	Organization	Type of aid
1	World Food Program (WFP)	Logistics, food, emergency telecommunications
2	International Federation of Red Cross	Shelter, non-food items
3	UNICEF	Water, sanitation and hygiene, nutrition, education
4	Pan American Health Organization / World Health Organization	Health
5	United Nations Development Program	Early recovery
6	International Organization for Migration	Camp coordination and management
7	Office of the High Commissioner for Human Rights	Protection
8	Food and Agriculture Organization of the United Nations	Agriculture

Table 6. List of NGOs (From Roux, 2011)

HA/DR operations are not new to the Navy, whose ships are frequently the first to arrive at a disaster to provide aid. However, unless trained and equipped for a specific kind of disaster, all they can bring is first-aid response, and rarely more. Navy ships are typically involved in only the first two phases of disaster relief (Kovacs & Spens, 2007). The Navy's main aim in HA/DR operations is to relieve or reduce the results of natural or

man-made disasters or other endemic conditions such as pain, hunger, or privation that might threaten life or property. Some activities include providing necessities and medical assistance, establishing communications, coordinating efforts among NGOs and the military and providing security. The Navy also guards supplies and HA/DR personnel against looters.

D. BOUNDARY

The disaster relief operations phases described by Kovacs and Spens form the boundary for this Systems Engineering study. Specifically, the HA/DR operations that are conducted or required from the U.S. Navy are studied in details, across the disaster relief phases. The U.S. Navy is most active in the immediate response phase, by providing immediate relief aid to the disaster victims in the shortest possible time. Prior to that, the U.S. Navy prepares itself to conduct HA/DR operations, by stocking on relief aid supplies, and conducting HA/DR training to its Sailors. The following sections describe the functions and mission requirements for the HA/DR operations within the disaster relief operations phases.

E. FUNCTIONAL DECOMPOSITION

While the Navy participates in the preparation and immediate response phase, (Kovacs & Spens, 2007), the reconstruction phase is the responsibility of the host-nation government, usually assisted by NGOs, which will remain in the host nation. After the disaster, the host-nation government will assess the damage and request international assistance. The U.S. DoD will generally receive a request for assistance and convert the request into military missions. Military forces, e.g., Navy ships, soldiers, etc., are then deployed to the region for HA/DR operations.

The functional decomposition in Figure 9 encompasses the entire spectrum of HA/DR operations, which might not necessarily be accomplished by the Navy alone. Understanding the functional decomposition of HA/DR operations will allow a better understanding of mission requirements, and therefore the suitability of Navy ships, especially LCSs, in HA/DR operations.

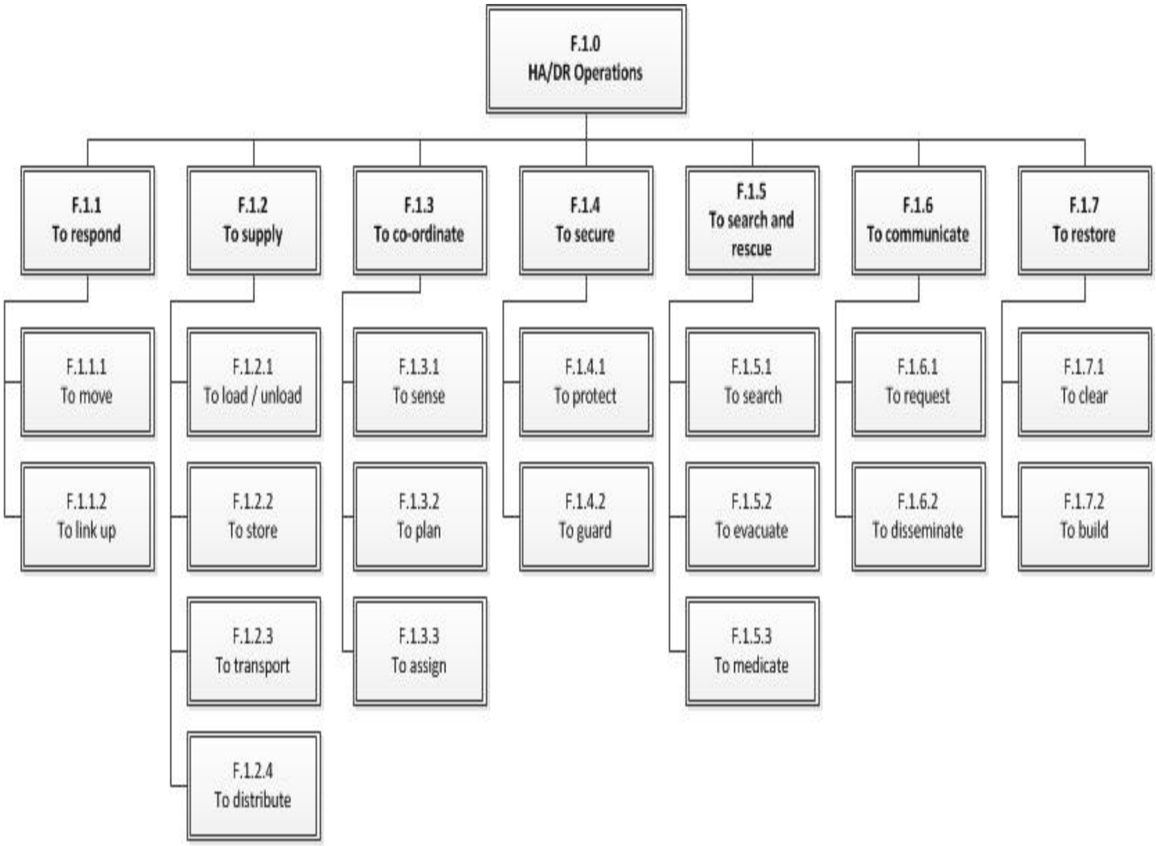

Figure 9. HA/DR Functional Decomposition

The functions required are described in detail in the following section.

F1.1 To respond

The request for assistance will be received by the DoD and translated into naval missions. Ships will be deployed to conduct HA/DR operations, sailing to the host nation (to move) and linking up with local authorities to commence operations (to link up).

F1.2 To supply

One of the most critical tasks in HA/DR operations is the provision of logistical supplies, for example, food, water, shelter, and medicine, to disaster victims. Supplies must be loadable on ships and unloadable for transportation and distribution (to load/unload). There must also be sufficient storage space on ship and at depots ashore (to

store). Transportation assets must be able to move the aid to centers (to transport) where they will be distributed to victims (to distribute).

F1.3 To coordinate

DoD has been at the forefront of recent HA/DR operations and is increasingly taking the lead. With the huge influx of HA/DR response by both military and non-military organizations, there may be confusion on the ground as to who’s in charge (DiOrio, 2010), causing undesirable delays. Hence, a vital function is coordination of the various HA/DR operations carried out by different agencies. For effective coordination, a good plan must be in place (to plan). A good plan depends on the accuracy of the information in the plan. In the chaotic environment right after a disaster, an all-encompassing global picture of the situation is essential to match available resources to needs. Information such as the number and location of victims, already available humanitarian resources, required humanitarian resources, and access to transportation is required for HA/DR operations planning (Roux, 2011). The ability to access and collect this information (to sense) is thus required to conduct planning for HA/DR operations. Proper assignment of tasks must be carried out according to plan, so that each agency is clear about its role (to assign). Lack of assignment may lead to duplication of effort, waste of limited resources, and missed opportunities to assist victims (Roux, 2011).

F1.4 To secure

The situation after a disaster is usually chaotic. Supply shortages may lead to increased crime, particularly looting and violence. For example, in Haiti, delays in relief distribution led to angry appeals from aid workers and survivors. Looting and violence were sporadic and a police presence was virtually nonexistent (DiOrio, 2010). The arrival of relief agencies may bring about a frenzied rush for supplies. A good security plan must be put in place to provide a safe and secure environment for humanitarian personnel, to benefit them and the victims (Roux, 2011). The plan is to protect the safety of HA/DR personnel (to protect) and guard supplies from looters (to guard) (Cohen, Quilenderino, Bubulka, & Paulo).

F1.5 To search and rescue

Another critical task of HA/DR operations is to provide search and rescue and medical aid. High numbers of deaths and injuries, missing persons, and destroyed infrastructure are characteristic of disasters. Thus, the need to save victims is top priority. Search missions must be conducted for victims swept away or trapped in debris (to search). The injured must be evacuated quickly to medical facilities, whether makeshift hospitals, surgical facilities aboard ships, or surviving hospitals (to evacuate), for immediate aid (to medicate).

F1.6 To communicate

The destruction of infrastructure may include destruction of communications infrastructure. Communication is required to request help (to request) and disseminate important information (to disseminate). A common communications system must be put in place, e.g., a website dedicated to the mission or a radio frequency that all agencies can use to transmit and receive data. Establishing a common mode of communication ensures that relevant and up-to-date information such as objectives, maps, and resources can be disseminated quickly.

F1.7 To restore

The restoration of the host nation to its original state is the responsibility of the local government and is an uphill task, depending on the amount of destruction and debris. This task often takes a long time. As an immediate response to the disaster, aid agencies must clear debris in the area of operations, e.g., seaports and airports, (to clear) and build vital infrastructure such as hospitals, main supply routes, and power infrastructure (to build) in order for HA/DR operations to proceed.

F. U.S. NAVY MISSION REQUIREMENTS

In 2011, Greenfield and Ingram conducted a thesis study and investigated the response of the U.S. Navy and the Military Sealift command to different types of natural disasters and identified the types of assets deployed as well as the dwell times for those assets. Using the recent history of the U.S. Navy humanitarian assistance and disaster

relief operations, Greenfield and Ingram explore opportunities to shape the fleet force structure to adapt to the increased mission importance of HA/DR operations. The study also analyzed disaster characteristics and the Navy platform capabilities, to determine which assets are better suited for mission requirements brought on by disasters. Greenfield and Ingram came up a list of the most common HA/DR mission requests received by Navy and the Military Sealift Command (MSC) shown in Figure 10. (Greenfield & Ingram, 2011). The list of missions was created by connecting common disaster traits with Navy and MSC capabilities.

Critical Missions		Aircraft support capability
		Amphibious Landing Craft support
		Search and Rescue (SAR)
	Cargo Capacity	Dry goods
		Refrigerated goods
		Fresh water
		Roll On Roll Off (RORO)
		Fuel
		Self sufficiency
		Personnel transfer
		Fresh water production
		Personnel support for cleanup and recovery efforts
		Berthing capability
		Medical support
Non-Critical Missions		Transit speed
		Hydrographic survey
		Salvage operations
		Towing capability

Figure 10. Standard HA/DR Mission Request (From Greenfield & Ingram, 2011)

1. Mission Requirements

The functional allocations from previous section translate to a set of basic HA/DR mission requirements that the Navy will need to conduct. As mentioned, the Navy will not fulfill all the HA/DR functions alone. Some of the tasks are conducted with the host

nation or NGOs. Other functions will either be tasked to the host nation or the NGOs. Figure 11 shows the functions, and who conducts them. The Navy will only provide HA/DR operations in the form of immediate relief aid, particularly to supply relief aid, co-ordinate relief aid efforts and also to provide security for HA/DR operations for the humanitarian actors.

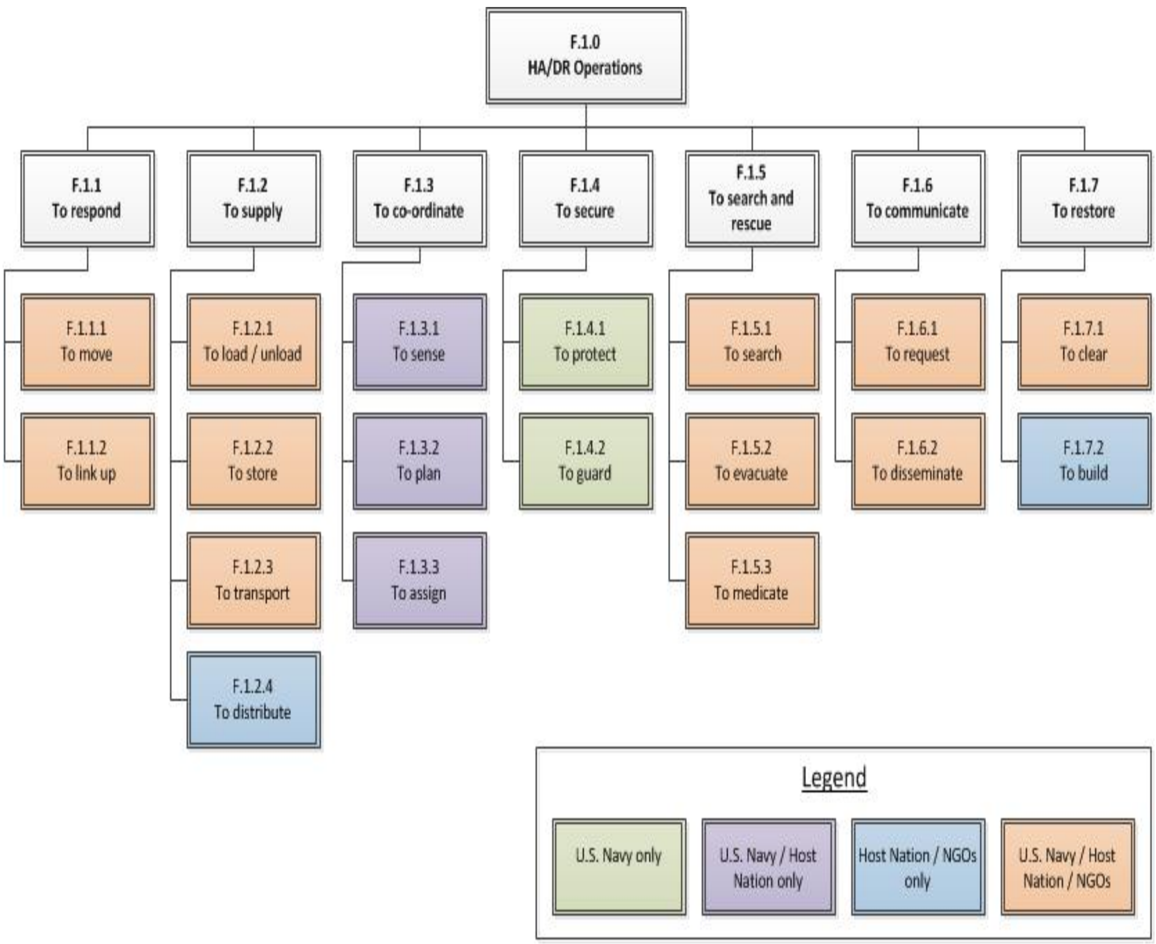

Figure 11. Functions of U.S Navy

The mission-request list from Greenfield and Ingram was used as a reference mission list and expanded to include mission requirements that were not formulated from the functional decomposition. Table 7 provides a list of the HA/DR mission requirements that the Navy will receive. The mission requirements are then translated to a set of

classification metrics for the assessment of the suitability of Navy ships, particularly LCSs, in this study of HA/DR operations.

<table>
<tr><th colspan="2">Mission Requirements</th><th>Mapping to functions</th></tr>
<tr><td colspan="2">Aircraft support capability</td><td>To transport</td></tr>
<tr><td colspan="2">Amphibious Landing Craft support</td><td>To transport</td></tr>
<tr><td colspan="2">Search and Rescue</td><td>To search
To rescue</td></tr>
<tr><td rowspan="6">Cargo Capacity</td><td>Dry goods</td><td>To store</td></tr>
<tr><td>Refrigerated goods</td><td>To store</td></tr>
<tr><td>Fresh water</td><td>To store</td></tr>
<tr><td>Roll On Roll Off (RORO)</td><td>To transport</td></tr>
<tr><td>Fuel</td><td>To store</td></tr>
<tr><td>Self-Sufficiency</td><td>To move</td></tr>
<tr><td colspan="2">Personnel transfer</td><td>To link up</td></tr>
<tr><td colspan="2">Fresh water production capability</td><td>To store</td></tr>
<tr><td colspan="2">Personnel support for cleanup and recovery efforts</td><td>To clear</td></tr>
<tr><td colspan="2">Berthing capability</td><td>To medicate</td></tr>
<tr><td colspan="2">Medical support</td><td>To medicate</td></tr>
<tr><td colspan="2">Transit speed</td><td>To move</td></tr>
<tr><td colspan="2">Hydrographic survey</td><td>To sense</td></tr>
<tr><td colspan="2">Salvage operations</td><td>To clear</td></tr>
<tr><td colspan="2">Towing capability</td><td>To clear</td></tr>
<tr><td colspan="2">Crane capability</td><td>To load/unload</td></tr>
<tr><td colspan="2">Planning and communications center capability</td><td>To plan
To assign
To request
To disseminate</td></tr>
<tr><td colspan="2">Self-defense capability (ship)</td><td>To protect
To guard</td></tr>
<tr><td colspan="2">Self-defense capability (personnel)</td><td>To protect
To guard</td></tr>
</table>

Table 7. Mission Requirements (After Greenfield & Ingram, 2011)

2. Mission Requirement Metrics

A set of classification metrics is developed from the mission requirements to provide a way to assess a ship's ability to conduct HA/DR operations and to compare ships of different types and capabilities with respect to HA/DR. The link between mission

requirements and ship capability is made with a three-step classification, shown in Table 8. The set of classification metrics is meant to indicate if a ship has the ability to conduct a specific mission and does not quantify the capability of the ship to do so, e.g., 30% capable of conducting a specific mission. The ship's capability is thus assigned one of three classification symbols, based on an ordinal scale of little/no capability, some capability, and very capable. The assessment of the ship was conducted by understanding the ships' capability and rating the capability with accordance to the classification.

Classification symbol	Classification description
○	Ship has little/no capability to conduct the specific mission.
◐	Ship has some capability to conduct the specific mission.
●	Ship is very capable of conducting the specific mission.

Table 8. Classification scale

The capability classification is defined in detail in Table 9.

Mission Requirement	Capability Classification	
Aircraft support capability	○	No helo capability, unable to support helicopter operations
	◐	Single helos on ship, able to support some helicopter operations
	●	Multiple helos on ship, able to support wide range of helicopter operations
Amphibious Landing Craft support	○	No ability to support amphibious landing craft
	◐	Some ability to support amphibious landing craft
	●	Able to store and support amphibious landing craft
Search and Rescue	○	No helo capabilities, unable to conduct SAR mission
	◐	Single helo, limited capability to conduct SAR mission
	●	Multiple helos, very able to conduct SAR mission

Cargo Capacity: Dry goods Refrigerated goods Fresh water Roll On Roll Off (RORO) Fuel Self-Sufficiency	○	No ability to store supplies beyond ship’s use
	◐	Some ability to store supplies beyond ship’s use
	●	Ability to store supplies beyond ship’s use
Personnel Transfer	○	No ability to transfer personnel
	◐	Limited ability to transfer personnel (up to 15)
	●	Ability to transfer larger number of personnel per voyage (more than 15)
Fresh water production capability	○	No ability to produce and transfer fresh water beyond ship’s usage
	◐	Some ability to produce and transfer water beyond ship’s usage of up to 2000 gallons per day
	●	Ability to produce and transfer water beyond ship’s usage of up more than 5000 gallons per day
Personnel support for cleanup and recovery efforts	○	Low crew number to support HA/DR operations (< 50 personnel)
	◐	Medium size crew to support HA/DR operations (51–200 personnel)
	●	Large crew to support HA/DR operations (> 200 personnel)
Berthing capability	○	Little to no excess berthing (< 30 racks)
	◐	Some excess berthing (31–50 racks)
	●	Larger number of excess berthing (> 50 racks)
Medical support	○	No ability to conduct impatient medical treatments
	◐	Some medical support available, ability to support minor medical procedures
	●	Medical support available, ability to perform surgeries and hold patients
Transit speed	○	0 – 18 knots max speed
	◐	19 – 24 knots max speed

	●	> 24 knots max speed
Hydrographic survey	○	No ability to conduct hydrographic survey
	◐	Some ability to conduct hydrographic survey
	●	Ability to conduct hydrographic survey
Salvage operations	○	No ability to conduct salvage
	◐	Some ability to conduct salvage in shallow waters
	●	Ability to conduct salvage, e.g., heavy lift and deep-water salvage operations
Towing capability	○	No ability to conduct towing operations
	◐	Some ability to conduct towing operations
	●	Ability to conduct towing operations, e.g., push, pull, or alongside towing operations
Crane capability	○	No ability to conduct crane operations
	◐	Some ability to conduct light crane operations
	●	Ability to conduct heavy crane operations.
Planning and communications center capability	○	No ability to conduct planning and communication operations
	◐	Basic planning and communications facilities available
	●	Fully equipped planning and communications facilities available
Self-defense capability (ship)	○	No or little ability for self-defense in littoral regions
	◐	Some capability of self-defense in littoral regions
	●	Built for littoral regions operations
Self-defense capability (personnel)	○	No or little ability for personnel self-defense on land
	◐	Some capability for personnel self-defense on land
	●	Capable for self-defense or combat operations on land

Table 9. Mission Requirements (After Greenfield & Ingram, 2011)

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IV. LCS FEASIBILITY IN HA/DR OPERATIONS

A. FEASBILITY STUDY

The feasibility of LCS in conducting HA/DR operations is studied in using the mission requirements in the following table. Aircraft Carriers (CVN Nimitz) (IHS Jane's, 2012c) and Amphibious ships (Land Ship Dock (LSD) and Landing Platform Dock (LPD) (Jane's, 2011)) are also studied using the same requirements, to compare between the ships. Both LCS Freedom and Independence class are included in the study. Only the basic LCS seaframe with basic components, e.g., helicopter support, sensor capabilities are considered in the study. Table 10 highlights the effectiveness of the Aircraft Carriers, Amphibious ships and LCS in their ability to conduct HA/DR operations.

				Cargo Capacity																		
	Aircraft Support	Landing Craft Support	Search and Rescue	Dry goods	Refrigerated goods	Fresh water	RORO	Fuel	Self-Sufficiency	Personnel Transfer	Fresh water production	Personnel support	Berthing	Medical Support	Transit Speed	Hydrographic survey	Salvage Operations	Towing Capability	Crane Capability	Planning and Communications	Self defense (ships)	Self Defense (personnel)
CVN (Nimitz)	●	○	●	◐	◐	◐	○	◐	◐	●	◐	●	●	●	●	○	○	○	◐	●	◐	◐
LPD (San Antonio)	●	●	●	◐	○	○	○	○	◐	●	○	●	◐	◐	◐	○	○	○	◐	●	◐	◐
LSD (Harpers Ferry)	●	●	●	◐	○	○	○	○	◐	●	○	●	◐	◐	◐	○	○	○	◐	●	◐	◐
LCS (Freedom)	◐	○	◐	○	○	○	○	○	○	◐	○	○	○	○	●	◐	○	◐	◐	●	◐	◐
LCS (Independence)	◐	○	◐	○	○	○	○	○	○	◐	○	○	○	○	●	◐	○	◐	◐	●	◐	◐

Table 10. Feasibility Study (From Greenfield & Ingram, 2011)

The over-arching mission of the U.S. Navy is to provide large amount of relief aid supplies to the disaster victims in the shortest possible time, and the capability of U.S. Navy to conduct HA/DR operations is best measured by the ability of the ships to deliver

the supplies. In summary, the ship's ability to carry and transfer cargo, its speed, and its ability to provide personnel and medical support is vital in HA/DR operations. The feasibility study table lays out an easy-to-understand matrix of the comparison of the Aircraft Carriers, Amphibious ship and LCS' ability to conduct HA/DR operations. It can be observed from the feasibility study table that Aircraft Carriers and Amphibious ships excel in the ability to conduct HA/DR operations. The Amphibious ships are able to conduct aircraft support, landing craft support, search and rescue operations, quick personnel transfers and medical support. The Aircraft Carriers allows for the storage of large amounts of cargo, personnel transfer and support, medical support and a high transit speed.

In comparison with the Aircraft Carrier and Amphibious ships, the LCS with its current set of mission packages seems to be slightly lacking in the ability to conduct HA/DR operations. The following sections describe the advantages and shortcomings of the LCS in HA/DR operations

1. Advantages

The main advantage of the LCS in conducting HA/DR operations is its high sprint speed. Its sprint speed of 40+ knots enables it to get to the disaster region much faster than the Aircraft Carriers and Amphibious ships. In conducting HA/DR operations, providing immediate relief aid is of utmost essence, and hence the faster the ship, the better the ability of the ship to deliver relief aid supplies. The faster the ship arrives at the disaster region, the faster the supplies and medication aid gets delivered, and the higher the chances that more disaster victims can get saved.

Unlike big ships like the Aircraft Carriers and Amphibious Ships, the LCS has a much shallow draft and thus has much more maneuverability in shallow waters, including the ability to dock at port with shallow waters. The current doctrine for Aircraft Carriers and Amphibious ships is to dock in deeper waters off the port, and to transport cargo and personnel via helicopters or landing crafts. The transportation of cargo and personnel via secondary means takes up a lot of resources, e.g., time and manpower. On the contrary, LCS, having a much shallow draft is able to dock at ports, and deliver cargo and

personnel straight to the disaster region. The unloading of cargo and personnel transfer will take much less time, and involves less logistics.

The LCS carries with it a full suite of sensors, such as the VTUAVs and OASIS. The LCS can deploy these sensors prior to reaching the disaster region, for a reconnaissance mission, and gain a better picture of the situation before reaching the port. This enables the commander to make plans for the organization of the HA/DR operations, once the ship has docked.

2. Shortcomings

The LCS has limited capacity to carry cargo and personnel. The LCS was designed to be combatant ship, and hence not meant to have a large cargo hold for the storage of cargo. Any available cargo space was meant to store necessities for the sustainment of the ship crew for sustained operations. This made it hard for the LCS to carry relief aid supplies for HA/DR operations. The LCS allows for a maximum of about 100 berthing facilities for Sailors (Martin , 2010) to operate both the seaframe and the mission packages. This means that there will only be 100 Sailors available to conduct HA/DR operations, which include unloading relief aid supplies, clearing of debris at port, conducting search and rescue missions, and provide security. This amount of manpower will not be able to accomplish the tasks, and hence leads to the LCS being unable to carry out the full suite of HA/DR operations effectively.

The LCS has limited medical support facilities onboard, and is not meant to cater to mass casualties or casualties suffering from severe injuries, e.g., requiring surgery. The only possible medical aid the LCS can offer could be the provision of limited quantities of medical supplies, and limited medical consultation, if there is a medical officer onboard the LCS.

The LCS also has limited endurance when travelling at sprint speed. An Operation Research (OR) thesis by John P. Baggett (Baggett, 2008) analyzed the LCS fuel consumption and endurance, and concluded that the LCS will have a threshold endurance range of 1,000nm at a sprint speed of 40kts. This limited endurance means that

either the LCS has to travel at a slower speed to travel further, or there is a need for re-fueling by the U.S. Navy Combat Logistics Force (CLF) in the midst of the journey.

B. LCS IRREGULAR WARFARE MISSION PACKAGES

The LCS may not be fully equipped and feasible for HA/DR operations with its current set of mission packages. The current three sets of mission packages focus on conducting surface warfare, anti-submarine and mine countermeasure missions effectively, but is far from ideal for HA/DR operations. A new mission package designed to equip the LCS with the HA/DR operations capability may enable the LCS to conduct HA/DR operations more effectively.

The Naval Seas System Command is currently developing a new LCS mission package focusing on Irregular Warfare (IW) operations, of which capabilities will fall towards humanitarian assistance and disaster relief-types missions. One of the main additions that the IW mission package will bring onboard is the additional medical support capability to care for disaster victims. Other than the IW mission package, the U.S. Navy is also developing a Maritime Security Mission (MSM) package. The combination of the MSM and IW mission packages will enable the LCS to be a vital tool in the U.S. Navy efforts to increase partner nation engagements around the world, especially in the Western Pacific (Munoz, 2012).

1. IW mission package considerations

A study on the possible equipment for the IW mission packages is conducted following the functional decomposition (Figure 9) and mission requirements (Table 7). The IW mission packages must allow the LCS to fulfill the functions required of the ship for HA/DR operations. Simply put, it must address the current deficiency of the LCS to conduct HA/DR operations. The following considerations must be taken into account for the design of the IW mission packages.

a. Modularization

Similar to the other mission packages, the IW mission package must also be modularized and be a ‘plug and play’ module for the LCS. Additionally, due to the

need for speed for HA/DR operations, it is essential that the installation of the IW mission package be as fast as possible, so that the LCS can quickly be installed with the IW mission package and embarks on the HA/DR operation.

b. Standardization

The range of equipment used for the IW mission package is desired to be the same as those from the other mission packages. This will help minimize logistical issues, such as maintenance and spares inventory. Having similar equipment also allows the changing of mission packages to be faster, since not all equipment will need to be unloaded and loaded. It is also cost efficient to share equipment due to savings in acquisition and Operations and Support (O&S) cost.

c. Training

Training has to be conducted to ensure that the LCS crews are able to operate the equipment in the IW mission packages. While this report does not study on the manpower requirement, it is unlikely that a separate crew be formed specifically for the IW mission package due to manpower shortages. As such, it is imperative that all LCS seaframe and the three mission package crews are able to operate the IW mission package.

2. IW mission package

A possible suite of equipment and the functions they fulfill is described in Table 11.

Mission Module	Features
Personnel Berthing and Support	- Berthing containers with multiple racks
Cargo capacity	- Storage containers - Refrigerated containers - Fuel containers - Water purification unit
Medical Support	- Surgical Container equipped with triage station, X-rays facilities, surgical facilities and blood bank - Medical personnel, e.g., doctors, surgeons and nurses.
Material Handling	- Fixed cranes - Portable cranes - Forklifts - Trolleys - Support containers
Search and Rescue	- MH-60S helicopter - Life detecting devices, e.g., LifeLocator® III+ (Geophysical Survey Systems, Inc)
Self Defense	- VBSS Gear

Table 11. IW mission package

a. Personnel Berthing and Support

More personnel support is achievable by using berthing containers to provide for berthing facilities on top of those already available on the LCSs. The berthing containers will provide for basic shelter and sleeping facilities for the crew. For other facilities, e.g., toilet, bathing and messing facilities, the crew will use those that are already built on the ship.

b. Cargo Capacity

Replacing battle essential equipment, e.g., sensors, ALMD and AMNS with storage containers can increase the cargo capacity of the ship. The storage containers may include the following equipment.

- Storage container – The storage container will be used for the carrying large amounts of relief aid supplies, e.g., bottled water, food, blankets and first aid equipment.

- Refrigerated container – Refrigerated container will be used for the storage of specific supplies, e.g., foodstuff and medicine.
- Water purification unit – The water purification unit is used to purify water for the disaster victims. The purified water will augment the supplies of bottled water in the storage container.

Figure 12. Water purification unit (From Bolch, 2005)

- Fuel containers – Fuel can be stored in containers to increase the endurance of the LCS. The fuel can also be provided to the host nation for their use.

c. *Medical Support*

Surgical containers may be installed on the LCS to enhance the medical capability of the ship in HA/DR operations. The surgical containers will come equipped with triage station, X-rays facilities, surgical facilities, blood bank and medical personnel, e.g., doctors, surgeons, medics and nurses. The surgical container will be able to augment the provision of medical aid to the disaster victims.

Figure 13. TransHospital's Operating Room module (From EADS North America, 2007)

d. *Material Handling Capability*

Material handling equipment is vital for the loading and unloading of the containers and relief aid supplies at the port. Containers and relief aid supplies have to be unloaded at the port for storage and distribution, and material-handling equipment will improve the effectiveness and efficiency of the unloading operations. The equipment includes fixed and portable cranes, forklift and trolleys.

e. *Search and Rescue Capability*

The aftermath of a disaster usually brings about extensive damage to the area, leading to missing or stranded victims. Search and rescue capability will enhance the LCS crew to help search for missing people, and rescue stranded victims. Aerial support, especially helicopters is a great asset in search and rescue missions. The helicopter is able to fly over damaged areas searching for victims, rescue stranded victims, and transport supplies. Life detecting devices, e.g., LifeLocator® III+ (Geophysical Survey Systems, Inc) can be used to detect life signs like breathing and movement, and hence be used to search for trapped victims.

Figure 14. LifeLocator® III+ (From Geophysical Survey Systems, Inc)

f. Self Defense Capability

The Navy is required to provide security to its own forces, as well as the relief aid supplies that are being delivered and stored at port against looters. Standard small caliber arms are sufficient as the main motive is to deter looters. The VBSS gear used in the surface warfare mission package can be used for this aspect of the HA/DR operations. The LCS seaframe self-defense capability is sufficient to deal with the defense of the ship.

3. Feasibility Study of LCS with Irregular Warfare mission package

A qualitative assessment on LCS with IW mission package is conducted with the same mission requirements. Table 12 highlights the effectiveness of the LCS with IW mission package in their ability to conduct HA/DR operations. With the inclusion of the IW mission package, the feasibility of LCS in performing HA/DR operations is improved, especially in areas of cargo capacity, personnel support, berthing and medical support. The IW mission package is able to mitigate the shortcomings of limited capacity to carry cargo and personnel as well as limited medical support.

	Aircraft Support	Landing Craft Support	Search and Rescue	Cargo Capacity: Dry goods	Cargo Capacity: Refrigerated goods	Cargo Capacity: Fresh water	Cargo Capacity: RORO	Cargo Capacity: Fuel	Cargo Capacity: Self-Sufficiency	Personnel Transfer	Fresh water production	Personnel support	Berthing	Medical Support	Transit Speed	Hydrographic survey	Salvage Operations	Towing Capability	Crane Capability	Planning and Communications	Self defense (ships)	Self Defense (personnel)
LCS (Freedom)	◐	○	◐	○	○	○	○	○	○	◐	○	○	○	○	●	◐	○	◐	◐	●	◐	◐
LCS (Independence)	◐	○	◐	○	○	○	○	○	○	◐	○	○	○	○	●	◐	○	◐	◐	●	◐	◐
LCS (Freedom) - IW	◐	○	●	◐	◐	◐	○	○	◐	◐	◐	◐	◐	◐	●	◐	○	◐	◐	●	◐	◐
LCS (Independence) - IW	◐	○	●	◐	◐	◐	○	○	◐	◐	◐	◐	◐	◐	●	◐	○	◐	◐	●	◐	◐

Table 12. Feasibility Study for LCS with IW mission package (From Greenfield & Ingram, 2011)

C. CONCEPT OF OPERATIONS

Despite having limitations in cargo and personnel capacity and lack of medical support, the LCS is still deemed as a feasible solution to conducting HA/DR operations, due to its high sprint speed, which allows the LCS to reach the disaster region faster than any other ships. By installing the proposed IW mission packages, previously identified shortcomings can be mitigated. By developing the HA/DR Concept of Operations (CONOPS) for the LCS, they can be better prepared to conduct HA/DR operations.

The LCS HA/DR CONOPS does not differ much from the combat CONOPS in terms of the employment. The LCS can be deployed as an integrated force with the CSG/ESG, as limited independent operations. When used for HA/DR operations, the LCS should be deployed for focused mission, which means that it should be installed with the appropriate mission package, e.g., IW mission package. This allows the LCS to

be suitably equipped with the capability to carry out HA/DR operations more effectively and efficiently. The following describes some of the vignettes and the CONOPs for LCSs conducting HA/DR operations.

1. Integrated with CSG/ESG

The LCS may be deployed as an integrated force with the CSG/ESG, when the entire integrated force is tasked for HA/DR operations. The integrated force will travel at the fastest possible speed, dictated by the slowest ship speed in the force. Depending on the distance travelled, there might be a need for the LCS to refuel. Refueling can be conducted either by CLF assets or from the ESG/CSG. The LCS is likely to be equipped with the SUW, ASW or MCM mission package and not the IW mission package.

Essential supplies should then be quickly transferred from the aircraft carriers or amphibious ships to the LCS, based on the availability of space. Essential supplies here refer to any relief aid supplies, such as food, water, medicine and shelter items. As the LCS is already equipped with a mission package, there might be insufficient space to load a large quantity of supplies on it. Wherever possible, the LCS should unload its combat equipment, such as sensors and weapons equipment onto the aircraft carrier and amphibious ship, to make space for the relief aid supplies. One example is that the VTUAV can be deployed to take off from the LCS, and to land onto the aircraft carrier or amphibious ship. The VTUAV container onboard the LCS can then be used to store relief aid supplies.

Upon reaching a predetermined location where the LCS can travel to the disaster country without re-fueling (approximately 1,000nm away from the destination), the LCS will break away from the CSG/ESG and travel at sprint speed to the disaster region to deliver the initial relief package. Upon reaching the disaster region, the LCS will link up with the local authorities, unload and hand over the relief aid supplies to the host nation, and survey the area. The survey report will then be sent to the CSG/ESG so that prior planning by the CSG/ESG commander can be conducted. Due to the small number of personnel support from the LCS, operations on the port will be limited. It is however

important that a small security force be set up for the protection of the troops and the guarding of the relief aid supplies.

The LCS will subsequently link up with the CSG/ESG when they have reached the disaster region, and assist in the subsequent HA/DR operations.

2. Independent Operations

The LCS can also be tasked to conduct the HA/DR operations independently. There are two vignettes that can happen – either the LCS is deployed from home, or the LCS is already out on limited independent operation and then deployed for HA/DR operations.

a. Deployed from home

The LCS deployed from home has the advantage of being installed with the IW mission package, and also packed with supplies specifically for HA/DR needs. The LCS crew can also be specifically selected and catered for HA/DR operations, such as personnel with experience in HA/DR operations, or personnel with specific expertise, e.g., doctors and surgeons.

b. Deployed in the midst of an independent operation

The LCS could be in the midst of a limited independent operation, when it was tasked to conduct the HA/DR operations. This scenario may be the least desirable, as the LCS would not have sufficient supplies, or manpower to conduct the HA/DR operations efficiently. Upon the tasking, the LCS will proceed to the disaster region at sprint speed. Depending on the distance to the destination, there may be a need for CLF assets midway to provide refueling to the LCS. Other than providing fuel to the LCS, the CLF assets can also replenish supplies, e.g., food, water so that the LCS has sufficient supplies to last the journey, and also be able to provide some to the disaster victims. This is important for the LCS, which is tasked for HA/DR operations when it is deployed in the midst of an independent operation. Upon reaching the disaster region, the LCS will link up with the local authorities, unload and hand over the relief aid supplies to the host nation. Due to the small number of personnel support from the LCS, operations on the

port will be limited. It is however important that a small security force be set up for the protection of the troops and the guarding of the relief aid supplies. The LCS will subsequently link up with other ships and continue HA/DR operations as required.

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V. CONCLUSION AND RECOMMENDATION

A. INCREASING NEED FOR HA/DR OPERATIONS

With the increasing number of disasters, there is an increase in HA/DR operations. The Navy has identified HA/DR operations as the leading OTW, and is increasingly taking the lead in coordination of HA/DR operations amongst the NGOs and other military forces. As such, every ship inventory of the Navy must be considered for its feasibility in HA/DR operations, in order to maximize the Navy's efforts in such operations.

B. FEASIBILITY OF LCS IN HA/DR OPERATIONS

The LCS is one of the newest ships in the Navy's inventory. The key highlight of the LCS is its high sprint speed and its modular design. Its high sprint speed enables it to get to places must faster than other ships, and also increases it survivability. Its modular design allows it to undertake different missions, with different mission packages, increasing its flexibility for combat operations.

A qualitative Systems Engineering study was conducted in this thesis to study the feasibility of the LCS in conducting HA/DR operations. The study includes the functional decomposition and the mission requirements of a HA/DR operation. The LCS was assessed using the mission requirements as an evaluation metrics. Despite the LCS having several advantages such as high sprint speed and shallow draft, there were some shortcomings in its ability to conduct HA/DR operation, including limited capacity for cargo and personnel, limited medical support and limited endurance.

C. POSSIBLE MISSION PACKAGE AND CONOPS

To overcome the shortcomings of the LCS in HA/DR operations, the IW mission package primarily for HA/DR operations was designed. Equipment within this mission package was derived from the functional decomposition of HA/DR operations, and will enable the LCS to conduct HA/DR operations more effectively and efficiently. The IW mission package helps the LCS mitigate some shortcomings in conducting HA/DR operations. A set of CONOPs were also developed, based on the vignettes of the LCS

being deployed as part of an integrated force with CSG/ESG or independently. The CONOPS developed will enable commanders to understand better the advantages and disadvantages of deploying LCS for HA/DR operations in the different vignettes.

In summary, the LCS by itself or with current mission packages has several shortcomings that rendered it not as feasible for HA/DR operations. It must be complemented with a specific logistical mission package, e.g., IW mission package to improve its capability.

D. RECOMMENDATION FOR FUTURE STUDIES

The Navy has already taken an interest in the development of the IW mission package for the LCS, with the aim of the mission package being used for HA/DR operations. Several in-depth, quantitative analytical studies should be conducted to study the type and quantity of equipment in the IW mission package, the number of IW mission packages required for the Navy, and also the deployment of the IW packages. Additionally, these studies should be able to demonstrate the possibility of measurable improvement in delivery of relief aid, security, and overall HA\DR mission performance, while including cost and risk considerations.

An optimization model of the number of LCS to deploy for HA/DR operations can also be conducted. While one LCS may not be sufficient to carry sufficient cargo and manpower, several LCS can be deployed as a HA/DR force. This HA/DR force will be able to carry much more cargo and manpower, and yet be able to get to the disaster victims fast to provide the relief aid supplies. However, there will be trade-offs, including high cost, and limitation in the numbers of available LCS and crew.

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